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**STATEMENT CLAIMING SMALL ENTITY STATUS
(37 CFR 1.9(f) & 1.27(b))--INDEPENDENT INVENTOR**

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Applicant, Patentee, or Identifier: Thomas N. Packard

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Title: System For Reducing Noise In The Reproduction Of Recorded Sound Signals

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04/05/99

APPLICATION OF: THOMAS N. PACKARD

FOR: SYSTEM FOR REDUCING NOISE IN THE REPRODUCTION OF
RECORDED SOUND SIGNALS

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BACKGROUND OF THE INVENTION

The present invention relates to the processing of electrical signals in connection with the recording and reproduction of sound, and in particular to the reproduction and the rerecording and playback of previously recorded sound signals.

10 The applicant is co-patentee of U.S. Patents 4,155,041; 4,151,471 and 4,259,742 and is sole patentee of U.S. Patent 4,322,641. These patents, which are incorporated herein by reference, are all concerned with the reduction of extraneous noises in the reproduction of analog sound recordings. These patents disclose three distinctly different and complementary systems for eliminating or reducing noises in the playback of old
15 cylinder and disc records. The first of these systems eliminates noises in the reproduction of monophonic disc or cylinder records by virtue of a switching process that selects reproduction from the momentarily quieter groove wall or from an equal mixture of the two, requiring that the recording be reproduced with two-track, stereophonic equipment. The second of these systems eliminates or greatly reduces the amplitude of noise transients
20 that remain after the switching process. The third system reduces the high frequency "hiss" that is not susceptible to reduction by the first and second systems. The second and third systems are applicable to both monophonic and stereophonic recordings.

The present invention provides new and improved means by which each of these three systems, individually and in combination, provides superior results in the reduction of noises and achieves major reductions in the artifacts which occasionally limited the versatility of the previous devices.

5 As used herein, the term "input signal" refers to the electrical signal, consisting of generally continuous and transient signals, bearing the audio information intended to be heard by the listener or receiver, plus noise signal. The term "noise signal" refers to the unwanted signals, both continuous and transient, which may be contained in the input signal. The terms "total signal", "signal plus noise" and "program plus noise" are
10 employed, depending on the context, synonymously with "input signal." "Program content" or "music signal" refer to the input signal less noise signal.

SUMMARY OF THE INVENTION

The first of the three signal processors or systems, termed the Switcher, takes advantage of the circumstance that imperfections in a recording such as particulate matter
15 in the record material, defects in manufacture, damage, dirt, wear, mildew, etc., which may introduce transient noises into the reproduction of the recording, are not usually identical on opposite sides of the record groove, whereas, in the case of monophonic phonograph recordings, the signals recorded on each side wall of the record groove normally are identical for all practical purposes. The prior invention, disclosed in
20 aforementioned U.S. Patent 4,259,742, reduces transient noises in the reproduction of a monophonic disc or cylinder recording by means of a three-way switching process between either of the groove's side walls or their average obtained by mixing equally the

signal on the groove's two side walls. Signals were transmitted simultaneously over each of two channels with a normally open, fast acting switch in each channel. The switch in the channel with the least signal plus noise was closed to transmit only the signal from that channel to the output. When the difference between signal plus noise on both channels was below a predetermined threshold value, both switches remained open and the signals on both channels reached the output through respective resistors with a third, voltage dividing resistor. This system was not effective in suppressing noise components of opposite polarity and non-matching amplitude. The present invention addresses this problem by simultaneously closing both switches, thereby delivering the average of the total signal on both channels to be conducted to the output.

The second of these three processors detects noise transients and in response thereto institutes a "blanking" action that limits both positive and negative pulsations of a transient so that they do not exceed a threshold value established relative to the momentary peak value of the signal in the vicinity of the transient. However, in some cases, in program material with very steep transients, such as commonly found in recordings of guitar, harpsichord, pizzicato strings and an occasional strongly attacked vocal note, the Blanker sometimes produced audible artifacts. It also had some trouble in distinguishing drum transients from noise transients, and in suppressing low level noise transients in low signal level areas. The Blanker of the present invention remedies these problems through the use of two fast acting switches, one of which interrupts only high frequency components of the noise transient and the other interrupting low frequency components.

The third system, a "Continuous Noise Suppressor", reduces noise of a continuous nature, usually referred to as "hiss" or, roughly, as "white noise", by means of an electronic circuit wherein the upper limit of the band width of the signal is automatically and continually adjusted in accordance with the relationship of (1) the peak amplitude of the rate of change of the signal with respect to time (i.e. the second derivative of the signal) to (2) the instantaneous amplitude of the signal within a selected frequency band. The Continuous Noise Suppressor disclosed herein has a more effective treble attenuation characteristic with a lower minimum cutoff frequency and a more rapid response to the changing dynamics of a recording, thus further reducing to the acute listener audibility of the continual modications of the cutoff frequency.

Brief Description of Drawings

Figure 1 is a schematic and block diagram representation of the switching system;

Figure 2 is a schematic diagram of the control circuit shown in block form in

Figure 1;

Figure 3 is a schematic diagram of an alternate embodiment of the control circuit;

and

Figures 4 and 5 are schematic diagrams of the Blanker and Continuous Noise Suppressor, respectively.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The three systems or processing stages for removing noises from sound signals emanating from such sources as sound recordings, radio broadcasts and the like, may be employed individually or in combination, as dictated by the requirements of the job at

hand. The first disclosed system, the Switcher, two signals which are substantially identical in program content, but which may differ in total signal amplitude due to differing noise content, are received simultaneously on respective channels and appropriate electronic circuitry compares to two input (total) signals and transmits to the recording or reproducing apparatus either: 1. an equal mixture (average) of the two input signals, or 2 the input signal on one of the channels. When that input signal has an amplitude which is lower than the average of the amplitudes of the two input signals by more than a predetermined threshold amount.

The Switcher

Referring now to Figure 1, there is illustrated a system which includes two input channels designated as Channel 1 and Channel 2. For the purposes of this description Channel 1 and 2 are presumed to be the two channels of a stereophonic playback system, although these channels can be the output of any device that is transmitting two signals that are identical in their program component but differ in their noise content. These two channels are connected to the signal sources such that the instantaneous voltage of the program component in each is of the same polarity.

The signals on Channel 1 and Channel 2 are applied to amplifiers 9 and 11 respectively. Associated with amplifier 9 are the fixed resistor 65 and the adjustable resistor 67. These two resistors govern the amount of negative feedback applied to amplifier 9, the gain of the amplifier being adjustable in accordance with the setting of adjustable resistor 67. The values of the two resistors can be chosen so that, when adjustable resistor 67 is set at its center point, the gain of amplifier 9 equals that of

amplifier 11, thus making it possible to adjust the gain of amplifier 9 over a considerable range of values both above and below the gain of amplifier 11, so that a considerable imbalance between the levels of the program component of the input signals (i.e. signal less noise) of Channels 1 and 2 can readily be compensated for. For the sake of simplicity, the signals being applied to Channels 1 and 2 will be assumed to be equal. However, it should be understood that signals of unequal magnitude can be accommodated by virtue of the adjustable gain of amplifier 9.

For optimum operation of the Switcher it is necessary to adjust the program component signal levels of the outputs of amplifiers 9 and 11 to equality with phase accuracy, which is achieved by providing amplifier 11 with a unity-gain, polarity-reversing switch (12) and then auditing the output of the Switcher with the switching action turned off. The gain of amplifier 9 is then adjusted with adjustable resistor (potentiometer) 67 for maximum cancellation of the program component i.e. minimum "music" signal via listening. This also allows one to audition noise components independently of the program component. The polarity reversing switch is to be switched back to the non-reversing position after the potentiometer adjusting procedure is concluded. The signals applied to Channels 1 and 2 would be of the same polarity when they are the output channels of a standard, two-channel, stereophonic record-playback system playing a lateral-cut monophonic recording. When reproducing a vertical-cut disc or cylinder with the same stereophonic record-playing system, the signals applied to Channel 1 would be of opposite polarity to those applied to Channel 2 and, in that case, the inverse of the above procedure would be employed.

The output terminal 13 of amplifier 9 is connected to the input 33 of low frequency attenuator 53 and also to input 49 of low frequency restorer 25. Similarly, the output 15 of amplifier 11 is connected to the input terminal 35 of low frequency attenuator 55 and to input terminal 51 of low frequency restorer 25. The output terminal 37 of low frequency attenuator 53 is connected to terminal 57 of a normally open, fast-acting switch 27 and also to input 21 of the control unit 19. The output terminal 39 of low frequency attenuator 55, identical to attenuator 53, is connected to terminal 59 of normally open, fast-acting switch 29 and also to input 23 of control unit 19. The output 61 of switch 27 is connected through resistor 60 to the input 43 of summer 31; output 63 of switch 29 is connected through resistor 62, to input 43 of summer 31. The output 41 of low frequency restorer 25 is connected to input 47 of summer 31. The output 39 of summer 31, which is the output of the Switcher, should be identical to the signal that is presented in Channel 1 and/or Channel 2 less the detected audible noise transients which the switching process has eliminated.

Resistor 101 is in parallel with switch 27 and resistor 102 is in parallel with switch 29. These two resistors are of equal value and, when switches 27 and 29 are both open, provide equal conductive paths to summer 31 from the outputs of both low frequency attenuators 53 and 55. These attenuators serve to eliminate from the switching process low frequency disturbances such as rumble, hum and thumps which either exist on a recording or may be introduced in the playback process. These attenuators also serve to protect the control unit from misoperations which could be caused if these disturbances were not filtered out. The integrity of phase relations within the program content of the

signal is preserved by designing the circuit of the low frequency restorer 25 to be an inverse complement of the low frequency attenuator circuits 53 and 55 such that the sum of the signals at 37 and 41 is identical in its frequency and phase relationships with that at output 13 of amplifier 9.

5 A first embodiment of control circuit 19 is shown in Figure 2, wherein inputs 201 and 203 correspond to control circuit inputs 21 and 23, respectively, of Figure 1. The inputs 201 and 203 are connected, respectively, to buffer amplifiers 205 and 207 that are identical in amplification. The outputs of buffer amplifiers 205 and 207 are connected to a bridging circuit consisting of resistors 209 and 211 that are equal in value and are joined at
10 junction 223. The inputs of full wave rectifiers 213 and 217 are connected to the outputs of buffer amplifiers 205 and 207, respectively, and the input of full wave rectifier 215 is connected to junction 223. The instantaneous signal voltage at junction 223 will be equal to the average of the instantaneous signal voltage at junctions 227 and 229. Thus the output of full wave rectifier 213 will be a fluctuating positive voltage that will represent
15 the absolute value of the instantaneous signal of Channel 1 after processing through the low frequency attenuator 53 of Figure 1. Similarly, the output of full wave rectifier 217 will represent the absolute value of the instantaneous signal of Channel 2 after passing through the low frequency attenuator 55 of Figure 1. As resistors 209 and 211 are identical in value, full wave rectifier 215, which receives its input from junction 223 of
20 these two resistors, the output of full wave rectifier 215 will represent at any given moment the absolute value of the average of the instantaneous signal of Channels 1 and 2.

The output 233 of rectifier 215 is connected to the negative input terminal of both subtraction circuits 219 and 221 through junction 216. The positive input terminal of subtraction circuit 219 is connected to the output 231 of rectifier 213, which derives its signal from Channel 1, and the positive input terminal of subtraction circuit 221 is connected to output 235 of rectifier 217, which derives its signal from Channel 2. The voltage differential between the input terminals of subtraction circuit 219 is expressed at output 249 and transmitted to the positive input terminal 237 of comparator 257. Similarly, the output 251 of subtraction circuit 221 is connected to the positive input terminal 243 of comparator 259. Voltage biasing devices 240 and 246 are connected to negative terminals 239 and 245 of comparators 257 and 259, respectively. The subtraction circuits 219 and 221 subtract the instantaneous voltage of their negative input terminal from the instantaneous value of their positive terminal, the results being delivered to terminals 249 and 251, respectively, which are connected to the positive input terminals 237 and 243 of comparators 257 and 259, respectively. The threshold point of operation of the comparators is chosen by means of a user-operated dual potentiometer that sets the same bias point at the negative input terminal of each, thus assuring an exact reciprocity of action in the noise reduction activities of each channel. The voltage at the circuit junctions (227, 229, 223, 231, 233, 235, 249, 251, 253 & 255) determine when the fast acting switches 27 and 29 (Figure 1) are opened or closed.

Operation of the control circuit of Figure 2 under each of these operating conditions will now be explained.

In Case 1 consider that signals substantially identical both in polarity and in amplitude are received simultaneously at Channel 1 and Channel 2. This case represents a momentary condition in which there is no appreciable noise component in either channel. Voltages at 227 and 229 are identical, or closely so, and the voltage at junction 223 is at the average of those at 227 and 229. The full wave, positive, pulsating waveforms at junctions 231 and 235, i.e., the outputs of full wave rectifiers 213 and 215, respectively, nearly match in value and polarity such that the difference voltage at the output 249 of the subtraction circuit 219 is negligible in normal operation of the device and at a value less than the user-adjusted positive DC voltage connected to the inverting input 239 of comparator 257. Thus, the output 253 of comparator 257 is insufficient to actuate the normally open fast acting switch 29 and terminals 59 and 63 (Figure 1) are not connected. Likewise, the positive, pulsating wave forms at 233 and 235 nearly match with the result that the difference voltage at 251 is negligible and at a value less than the pre-established positive voltage connected to the inverting input of comparator 259. The output 255 of comparator 259 is too low to actuate the normally open fast acting switch 27. Thus, terminals 57 and 61 are not connected. Consequently, equal value resistors 101 and 102 conduct signals from low frequency attenuators 53 and 55 to summer 31, In this manner, when there is negligible noise and, thus, the instantaneous signals of Channel 1 and Channel 2 are identical, or almost so, the output of summer 31 provides a monaural mix of the signals received at Channels 1 and 2.

In Case 2 consider that an instantaneous voltage is received at the input of Channel 1 and that a lesser input voltage of the same polarity is received at the input of Channel 2,

simultaneously applying a voltage, V , at 227 and a voltage, kV , at 229, where k is a positive number between 0 and 1. The voltage resulting at 223 will be the average of the two voltages, namely $(k+1)V/2$. The voltages at 227, 223 and 229, after undergoing full wave rectification, will be expressed as positive voltages at 231, 233 and 235 that will have values, respectively, of V^1 , $(k+1) V^1/2$ and V^1 . The voltage at 249 is equal to the voltage at 231 minus the voltage at 233 or $(1-k) V^1/2$. Since k has a value between 0 and 1, the voltage at 249 is positive. Through the conditions posited for Case 2, the magnitude of the positive voltage at 249 exceeds the magnitude of the positive, pre-established, user-adjustable voltage at the inverting input of comparator 257. The output at 253 is high, resulting in a connection between terminals 59 and 63 of the fast-acting switch 29, as the resistance of closed fast-acting switch 29 is much smaller than that of resistor 102. The voltage at 251 is the voltage at 235 minus the voltage at 233, or $(k-1) V^1/2$. Since k is between 0 and 1, the voltage at 251 is negative. This negative voltage at 251 and the positive, pre-established voltage at the inverting input 245 of comparator 259 result in output 255 being low. Consequently, fast acting switch 27 remains in the open position. Summer 31 accepts signals from Channel 1 through resistor 101 and from Channel 2 through fast acting switch 29. Since the resistance of closed switch 29 is much smaller than the resistance of resistor 101, and in consideration of the voltage divider action between two resistances, the signal from Channel 1 is not conducted. In this manner, when there is noise in Channel 1 and a lesser amplitude of the same polarity in Channel 2, the output of summer 31 delivers only the signal received in Channel 2, Through a similar consideration, should the greater instantaneous voltage of the same

polarity be received at Channel 2, the output of summer 31 will deliver only the signal received at Channel 1.

In Case 3, consider that an instantaneous voltage is at Channel 1 and that an instantaneous voltage of opposite polarity and lesser amplitude is received at Channel 2, Channel 1 providing a voltage, V , at 227 and Channel 2 providing a voltage, $-kV$, at 229, where k is a positive number between 0 and 1. The voltage at 223 will be $(1-kV)/2$, the average of the voltages at 227 and 229. The voltages at 227, 223 and 229 are then full-wave rectified by rectifiers 213, 215 and 217, respectively. Note, in particular, that although the voltage at 229 which enters full wave rectifier 217 is negative, namely $-kV$, the voltage at 235 will be the positive quantity represented by kV^1 . The voltage at 249 will equal the voltage at 231 minus the voltage at 233, or $(1+k)V^1/2$. Through the conditions posited for Case 3, and the magnitude of the positive voltage at 249 exceeds the magnitude of the positive, pre-established voltage at the inverting input 239 of user-adjusted comparator 257 in normal operation of the device. Consequently, fast acting switch 29 will close, connecting terminals 59 and 63. The instantaneous signal at 251 is a linear function of the voltage at 235 minus the voltage at 233, i.e. $(3k-1)V/2$. If k has a positive value between 0 and $1/3$, the polarity at 251 is negative, the output of comparator 259 is low and fast acting switch 27 will remain open, If k is a positive number between $1/3$ and 1 and, through the conditions posited as Case 3, the magnitude of $(3k-1)V^1/2$ exceeds the positive, pre-established, user-adjusted voltage at the inverting input 245 of comparator 259, then the output of comparator 259 assumes a value sufficient to close fast acting switch 27. In this manner, when the magnitude of the instantaneous voltage of

Channel 2 is between 1/3 of and equality with the instantaneous voltage of Channel 1, and of opposite polarity, the circuit chooses an equal mixture (i.e. the average) of Channels 1 and 2. Through the foregoing process of analysis, it can be demonstrated that if the magnitude of the instantaneous voltage of Channel 1 is between 1/3 of and equality with the instantaneous voltage of Channel 2 and of opposite polarity the output of the circuit is also an equal mixture (i.e. the average) of Channels 1 and 2.

Figure 3 illustrates another control circuit that can be used in place of the preferred circuit just described. Input buffers 301 and 302 of the Figure 3 embodiment serve the same functions and circuit positions as do buffers 205 and 207, respectively, of Figure 2, and the outputs of OR gates 311 and 312 operate switches 27 and 29, respectively, of Figure 1 in the same manner as comparators 257 and 259 of the control circuit of Figure 2. Full wave rectifiers 305 and 306 track the absolute magnitude of the instantaneous peak value of the input signal (i.e. program plus noise) of input Channels 1 and 2 respectively. The output of rectifier 305 is connected to the positive input terminal of subtraction circuit 308 and the output of rectifier 306 is connected to the negative input terminal of subtraction circuit 308. The output of subtraction circuit 308 connects to both the positive input terminal of comparator 309 and the negative input terminal of comparator 310. The negative input terminal of comparator 309 receives a positive D.C. bias from a user-adjustable voltage source 313 and the positive input terminal receives a negative D.C. bias from a user-adjustable voltage source 315. The user-adjustment is accomplished by means of two concentrically mounted linear taper potentiometers identical in value, so as to provide bias voltages at comparators 309 and 310 equal in

value though opposite in polarity. The output of comparator 309 connects to one input of OR gate 311 and the output of comparator 310 connects to an input of OR gate 312.

The output of subtraction circuit 308 is positive when the instantaneous absolute voltage of Channel 1, as transmitted by buffer 301 and full wave rectifier 305, exceeds in magnitude the instantaneous absolute voltage of Channel 2, as transmitted by input buffer 302 and full wave rectifier 306. If the positive output from the subtraction circuit 308 exceeds the pre-established positive voltage at the inverting input of comparator 309, comparator 309's output is a positive voltage. As a result, the output of OR gate 311 is assured of being a positive voltage irrespective of the polarity of its other input, thus causing fast-acting switch 29 to close. Thus this signal from Channel 2 is received by summer 31 while signal from Channel 1 is excluded. Conversely, the output of subtraction circuit 308 is negative if the instantaneous absolute value of the input signal (i.e. program plus noise) voltage of Channel 2 exceeds in magnitude the instantaneous absolute value of the input signal voltage of Channel 1. If the negative output voltage from subtraction circuit 308 exceeds the pre-established negative voltage at the non-inverting input of comparator 310, the output of comparator 310 assumes a positive value. The output of OR gate 312 goes high irrespective of the voltage state of its other input and fast acting switch 27 is closed. This results in signal from Channel 1 being received by summer 31 (Figure 1) at the exclusion of signal from Channel 2. In this manner, when there is noise in Channel 2 and a lesser noise in Channel 1, the output of summer 31 is only the signal from Channel 1. The positive inputs of comparators 303 and 304 are connected to the outputs of buffers 301 and 302, respectively. The negative inputs of comparators 303 and 304 are

connected to ground. The output of comparator 303 goes positive when the voltage from buffer 301 is positive with respect to ground. The output of comparator 304 goes positive when the voltage from buffer 302 is positive with respect to ground. The outputs of comparators 303 and 304 are connected to the two inputs of EXCLUSIVE OR gate 307.

5 The output of EXCLUSIVE OR gate 307 goes positive if the output of comparator 303 alone or 304 alone is positive. Expressed differently, EXCLUSIVE OR gate 307 is negative if the signals on Channels 1 and 2 are of the same polarity, and the output of EXCLUSIVE OR gate 307 is positive if the signals on Channels 1 and 2 are of opposite polarity. The output of EXCLUSIVE OR gate 307 is connected to the other inputs of OR
10 gates 311 and 312. If the output of EXCLUSIVE OR gate 307 is positive, the outputs of OR gates 311 and 312 are positive irrespective of the voltage applied at their other inputs. Fast acting switches 27 and 29 both close, imparting a monaural mix of signals from Channels 1 and 2 to summer 31. As has been described, the alternate embodiment represented in Figure 3 produces the same actions as the embodiment in Figure 2, except
15 in the case of input signals in Channels 1 and 2 having opposite polarity. The Figure 2 embodiment enables a monaural mix of the input signals when the input signals are of opposite polarity and have amplitudes within 30% of each other. Whereas the embodiment of Figure 3 enables a monaural mix of the two signals if the signals are of opposite polarity at all relative levels to each other.

20 In some situations where it is not necessary or desirable to suppress "ticks" or other transient noise components, there may exist dropout, fading or other sudden changes in the level of the input signal which it may be desired to alleviate. The latter object can be

achieved with the circuit in Figure 2, modified by connecting the input of rectifier 213 to junction 229 (the output of amplifier 207) thereby deriving signal from Channel 2, and connecting the input of rectifier 217 to junction 227 (the output of amplifier 205) thereby deriving signal from Channel 1. Outputs from subtraction circuits 219 and 221 and comparators 257 and 259 are now reversed and the operations of fast-acting switches 27 and 29 are also reversed. Thus, the fast-acting switches 27 and 29 that normally function to assure the transmission of signal from the channel that has the lesser total instantaneous signal level with respect to the average signal of the two channels will now function to secure transmission of the signal from the channel that has the greater instantaneous total input signal level. By replacing the permanent connections shown in Figure 2 between the input of rectifier 213 and junction 227 and the permanent connection between the input of rectifier 217 and junction 229 with a reversing switch, one can achieve, with one piece of equipment, the two modes of operation. Such a switch is also useful in demonstrating and testing the operation of the Switcher by comparing the noise audible in the two different positions of the switch. This feature is disclosed in earlier referenced Patent No. 4,259,742.

The Blanker

After processing by the Switcher the signal next enters the Blanker, a preferred embodiment of which is shown in Figure 4.

This processor limits the amplitude of noise transients by dividing the signal channel into a high frequency path and low frequency path wherein high frequency noise transients are limited in accordance with the peak amplitude of the program component in

the vicinity of each individual noise transient and noise transients in the low frequency path are discriminated from program transients by virtue of the noise transients' high frequency content and limited in accordance with the peak amplitude of the low frequency path's program content in its vicinity. The two paths are then re-united such that the signal exiting the Blanker is identical with the input signal save for the suppression of the noise transients.

The incoming signal is applied simultaneously to the input of high pass filter 405 and to low pass filter 407, thus dividing the signal into two branches, in one of which the low frequency transient noises are to be eliminated or suppressed and in the other of which the high frequency transient noises are to be eliminated or suppressed. High pass filter 405 has a low frequency attenuation characteristic of 12 db per octave with its turnover frequency at 800 Hz and low pass filter 407 has a characteristic inversely complementary to that of 405 starting, also, at 800 Hz , such that signal paths 430 and 432, when re-combined in mixer 427, will become a signal identical to the input signal with the exception that noise transients have been eliminated or suppressed.

The elimination of transient noises is effected by switch 401 for the high frequency signal path and by switch 403 for the low frequency signal path. Both switch 401 and switch 403 are fast-acting, normally closed switches. Each switch opens whenever its control circuit detects a noise transient that is to be eliminated. The charge on either capacitor 423, connected to the output terminal 402 of switch 401 to ground, or on capacitor 425, connected to the output terminal 404 of switch 403 to ground, serves to provide a signal continuity in its path during the brief time that the switch is open.

Switch 401 is triggered to open by comparator 424 when the voltage at the negative input terminal 463 of comparator 401, which is derived from the total signal (program plus noise) at the output of high pass filter 405, exceeds the voltage at positive input terminal 426 of comparator 401, which voltage is indicative of the “signal without noise” level from high pass filter 405, as follows: The output of high pass filter 405, the characteristics of which were described above, has a connection to the low pass filter and time delay unit 404. Filter 404 has an 18db per octave high frequency attenuation characteristic with its turnover frequency at 3 kHz. Since the signal entering filter 404 had previously undergone an attenuation of low frequencies of 12 db per octave starting at 800 Hz, the signal emerging from filter 404 has had its components below 800 Hz and above 3 kHz drastically diminished in magnitude. The frequency range below 3 kHz is the range in which the program content of the input signal dominates over high frequency surface noise of recordings such that the output of filter 404 can successfully be taken as representative of the level of signal without high frequency noise. In addition it is not desirable that transients or program material below 800 Hz influence the operation of switch 401. The output of filter 404 is connected to the input of full wave rectifier 406 the output of which is connected to junction 408. Thus, junction 408 registers the momentary absolute value of signal from filter 404. Resistor 410 is connected between the output of full wave rectifier 406 and the input of rectifier 416. Rectifier 406 in conjunction with capacitor 415 and potentiometer 420, both connected to ground, serves as a peak detector. Should the voltage at rectifier 416 diminish, the voltage on capacitor 415 discharges through the resistance of potentiometer 420, the discharging time constant

chosen to be approximately 100 milliseconds. The slider of potentiometer 420 is connected to the input of D.C. amplifier 422, the output of which is connected to the positive input terminal 426 of comparator 424. Thus, the relatively slowly discharging voltage at the output of peak detector (rectifier) 416 is providing, by means of user-adjustable potentiometer 420 and D.C. buffer amplifier 422, threshold voltage at positive terminal 426 of comparator 424, this threshold voltage being representative of the ever-changing absolute value of the program content (signal-without-noise) of the signal. The output of high pass filter 405, expressing high-frequency components of the input signal, is connected to full wave rectifier 409, which has no capacitor associated with it to slow its charging or discharging time, thus constituting a tick detector. The output of rectifier 409 is connected directly to negative terminal 463 of comparator 424. When a tick whose frequency content exceeds 3 kHz occurs and the positive voltage at input 463 exceeds the positive voltage of input 426 of comparator 424 thereby, the output of comparator 424 becomes sufficiently negative to open switch 401. Thus, the ticks exceeding approximately 3 kHz are not transmitted from high pass filter 405 to mixer 427 when the tick amplitude exceeds the threshold voltage at terminal 426, which is governed by the sum of the voltage output of peak detector 416 and, furthermore, by the setting of user-adjustable potentiometer 420. Low frequency noise transients are typically caused by scratches, needle drops and cracks in the record. Playback of these yields loud noise transients, rich in both low and high frequencies. Music instruments that produce strong low frequency transients, most notably drums, are far less rich in high frequency transients than are the scratches, needle drops and cracks. Thus, we are provided with a useful

criterion for distinguishing between loud, low frequency noise transients and low frequency music transients.

Low frequency noise transients are suppressed by opening fast acting switch 403.

Switch 403 is controlled by NAND gate 421 and opens if the output of NAND gate 421 is

5 sufficiently negative, which requires that positive voltages be applied simultaneously to terminals 434 and 436 of NAND gate 421. Input terminal 434 is connected to the output of comparator 419 which is a positive voltage when the positive instantaneous voltage at the output of full wave rectifier 411 connected to the positive input terminal of

comparator 419 exceeds the positive voltage at the negative input terminal of comparator

10 419. The positive input terminal of comparator 419 is connected to the output of full wave rectifier 411, the input of which is connected to the output of low pass filter 407.

The negative input of comparator 419 is connected to the output of a peak detector

consisting of rectifier 417 and resistor 457 feeding capacitor 451 and resistor 453, the

latter both connected to ground. The purpose of resistor 457 is to provide a time delay of

15 approximately five milliseconds in the charging of capacitor 451 so that the voltage at the

output of peak detector, junction 459 is not affected by short noise transients. The input

of full wave rectifier 411 is connected to the output of low pass filter 407 and the input of

rectifier 417 is connected to the output 435 of full wave rectifier 409. The input of full

wave rectifier 409 is connected to the output of high pass filter 405. The values of

20 capacitor 451 and resistor 453 are chosen to provide a discharging time constant of

approximately 20 milliseconds. The discharging time constant provides some short term

stability to the voltage serving as bias voltage to the negative input terminals of

comparators 419 and 441. The positive input terminal of comparator 441 is connected to the junction of resistors 428 and 429. The other end of resistor 428 is connected to ground and the other end of resistor 429 connects to junction 435 the output terminal of full wave rectifier 409. Resistors 428 and 429 attenuate the voltage derived from junction 435 in order that switch 403 opens only in response to large amplitude, high frequency noise transients, i.e., those that exceed the peak program content by a factor of three or more, as lesser noise transients do not typically have enough low frequency content to warrant a blanking procedure in the low frequency signal path. If the transient at the positive input terminal of comparator 441 received from rectifier 409 and high pass filter 405 exceeds the peak signal at 459, its negative input terminal, the output of comparator 441 becomes sufficient to trigger monostable multivibrator 443. The output voltage of multivibrator 443 closes fast acting switch 414 for approximately 1.5 milliseconds. When fast acting switch 414 is closed, the signal at the output of resistor 410 is shorted to ground.

Filter 404 is intended to feed "music" signal through rectifier 406 through peak detector 416, buffer amplifier 422 and to the input 426 of comparator 424. The 3 kHz corner frequency selected for filter 404 is suitable for eliminating high frequency ticks but may pass some low frequency tick transients. Due to the delay in filter 404, control switch 414 will be triggered to close before the low frequency transient appears at the output of filter 404. During the 1.5 milliseconds that switch 414 is closed, the 100 millisecond time constant of the circuit at the output of peak detector 416 serves to maintain the voltage that it had just before switch 414 closed, so that the circuitry that operates switch 401 will

be undisturbed by low frequency noise transients having frequency components below 3 kHz. The output of monostable multivibrator 443 also connects to the second input 436 of NAND gate 421. When there is a tick having sufficient amplitudes determined both above and below 3 kHz, there is sufficient positive voltage at inputs 434 and 436 to make the output at NAND gate 421 sufficiently negative to open switch 403. In this manner the low frequency ticks at low pass filter 407 are not transmitted to mixer 427. If desired, visual indicators of operability of either of both of switches 401 and 403 may be provided. For example, light emitting diode 461 is connected to the output of comparator 424 and, through series resistor 462, to ground without compromising the output voltage of the comparator driver. When the output of the comparator goes low, light emitting diode 461 illuminates to indicate opening of switch 401.

The Continuous Noise Suppressor

The input of the system shown in Figure 5 is connected to buffer amplifier 501. The output of the buffer amplifier connects to the input of voltage controlled filter 502, the output of which connects to the input of voltage controlled filter 503, the output of which connects to the input of amplifier 504, which is the output amplifier of the Continuous Noise Suppressor system. Each of the voltage controlled filters has a high frequency attenuation characteristic of 6 db per octave with the turnover frequency being directly proportional to a control voltage applied simultaneously at terminals 507 and 508, respectively, of the filters 502 and 503 by the control unit, the components and configuration of which are diagrammed below the dashed lines in Figure 5. Voltage controlled filter 503 is designed so that its cutoff frequency is approximately an octave

above the cutoff frequency of filter 502 for all values of the control voltage applied to each simultaneously, thus producing at the output of filter 503 a response curve that will be at an attenuation rate of 6db per octave for the first octave of attenuation and at a rate of 12 db per octave starting at the second octave of attenuation. This attenuation curve
5 was determined to be more subtle and effective in listening tests than is the previously employed curve of 8 db per octave with no inflexion point that was employed in the unit described in U.S. Patent No. 4,322,641.

The comparison and control means, which are diagrammed below the dashed lines in Figure 5, has two branches. The upper branch, which is representative of the "music"
10 content of the signal, receives its input from the output of input buffer amplifier 501. The signal in this branch is processed through band pass filter 505, with corner frequencies of approximately 1 kHz and 3 kHz. The output of the band pass filter 505 connects to the input of a peak detector which consists of full wave rectifier 507, resistor 509 and capacitor 517. Resistor 509 connects the output of rectifier 507 to the input 524 of
15 voltage divider integrated circuit 525 and also to capacitor 517 and resistor 519, the other side of each of the latter two being grounded. The full wave rectified voltage appearing at terminal 524 is taken as representative of the program component of the total signal.

In the lower branch of the control circuit the signal passes successively through two differentiators 511 and 513 in series. The output of differentiator 513 is connected to
20 a peak detector consisting of full wave rectifier 515, resistor 516 and capacitor 521. Resistor 516 connects the output of rectifier 515 to input 526 of voltage divider integrated circuit 525 and also to capacitor 521 and resistor 523, the other side of each of the latter

two being grounded. The signal at 526 is representative of the rate of change of the rate of change (i.e. of the acceleration component) of the input signal. Values of capacitor 517 and resistor 519 are chosen to provide a time constant of approximately five milliseconds, thus producing some short term stability of the signal at 524 and also playing a role in desensitizing the unit from being disturbed by noise transients, as the value of resistor 509 is chosen to provide, in combination with capacitor 517, a time constant of approximately 2 milliseconds. Similarly, in the lower branch, capacitor 521 and resistor 523 have a time constant of about 2.5 milliseconds and capacitor 521 and resistor 516 are chosen to produce a time constant of approximately 1 millisecond. Noise transient de-sensitization is needed when this processor is employed as a stand-alone device. However, noise transient de-sensitization is accomplished by the addition of only two resistors (509 and 516) and is also beneficial should an unexpected noise transient succeed, at least in part, in getting through the two previous processors. The output voltage divider integrated circuit 525 provides a voltage that is proportional to the ratio of the voltage at terminal 524 to that at terminal 526. Resistor 527 is connected between the output of integrated circuit 525 and the high end of potentiometer 529. The slider of potentiometer 529 goes to input 532 of mixer 531 and the other end of potentiometer 529 goes to ground. Potentiometer 529 is user-adjustable and is labeled "Ceiling". The other input terminal 534 of mixer 531 is connected to a D.C. bias arrangement symbolized by a D.C. voltage source 535 with a potentiometer 533 in series with resistor 537 connected across it. This potentiometer is also user-adjusted and is labeled "Floor". The slider of potentiometer 533 provides a user-adjusted means of applying a steady-state voltage to the input 534 of mixer 531.

Consequently, the voltage at the output terminal of mixer 531 will be representative of the sum of the fluctuating voltage output of ratio detector 525 and the user-adjusted bias voltage. The voltage at the output at mixer 531 is applied to the control inputs of both filters 502 and 503. The output of mixer 531 is also connected to the input of meter 539,
5 which is provided with a scale calibrated to read the cutoff frequency of filter 502 as a function of the voltage at the output of mixer 531.

Thus, the momentary cutoff frequency is determined by the sum of the steady bias voltage, user-adjusted by the slider of potentiometer 533, and by the varying voltage from circuit 525, the effect of which is regulated by the user-adjustable slider of potentiometer
10 529; the higher the sum of the two voltages, the higher the cutoff frequency. When no signal is applied to the input of buffer amplifier 501 the cutoff frequency reading of meter 539 and the configuration of the low pass filters 502 and 503 will be a steady value dependent on the slider setting of potentiometer 533. Then, when one starts to play a record, the meter needle will immediately become active as the voltage at the slider of
15 potentiometer 529 is added to that from the slider of potentiometer 533 in the mixer 531. When the music component of the total signal is strongest the ratio of the voltage at input 524 to that at 526 will be at its highest value. By adjustment of the slider of potentiometer 529, the user selects the fraction of the voltage that will enter 532 to add to the D.C. voltage from the slider of potentiometer 533 and, consequently, raise the cutoff
20 frequencies of filters 502 and 503. This voltage is also applied to the meter 539 which now will be reading the instantaneous values of the varying output voltage of mixer 531, which the meter shall indicate as cutoff frequency. Meter 539 is an important aid to the

user, adding the faculty of vision as a valuable supplement to the sometimes difficult-to-judge auditory perceptions of the Continuous Noise Suppressor output.

Summary

The invention described herein thus effectively reduces noises in sound signals in a manner which is not audibly discernible and does not impair the quality of the sound signal. The circuit of the preferred embodiment is both practical and economical and is effective in use.

In the Switcher of the prior art, the magnitudes of the two channels were compared and if they differed by a sufficient amount indicative of transient noise components, the channel having the lesser magnitude was transmitted to the output of the Switcher. In this manner only one channel or the other was enabled through the closure of the channel's fast acting switch, or, in cases of noise below a threshold value in both channels, both switches remained open. While the prior art device was effective for the reduction of noise occurring as momentary and separated events between the two channels it failed to address the added possibility of noise occurring simultaneously in the two channels. In particular, during the instances of simultaneous noise there is the possibility of the noise components being of opposite polarity but of non-matching amplitude such that the best approximation of the music component is the average of the total signals of the two channels. The present invention is able to address such instances by enabling both channels to be conducted to the output of the switcher through simultaneous closure of the two fast acting switches, one switch located in each channel. This and other aspects of

the present invention furthermore allow a more sensitive and effective threshold of operation.

The noise transient was recognized by the prior art Blanker as total signal having greater amplitude than in a preceding, pre-established interval of the total signal. A fast acting switch responded to detected noise transients, serving to interrupt transmission of the noise transients to the output of the blanker. However, the device would sometimes remove the leading edges of desired music transients, particularly music transients having low frequency components such as drum beats, voice and piano. This problem has been remedied in the present invention by utilizing two fast acting switches. The first switch is designed to interrupt only the high frequency components of the noise transient and thereby mitigate the possibility of its distorting low frequency music. The second switch is designed to interrupt only the low frequency components of the noise transient. In another aspect of the invention, the second fast acting switch is enabled only when sufficient levels of high frequency signal is detected, thereby opening upon the occurrences of deep scratches in the recording medium and, in general, during noise events typically having high frequency spectra, but prevented from opening upon the occurrences of music transients of low frequency.

In the prior art continuous noise, otherwise known as white noise or hiss, was separated from the total input signal through differentiation. The total input signal was also processed through a band pass filter such that the output represented a pre-selected frequency portion of the music content within the total input signal. The magnitudes of the noise content and music content thus derived were compared to form a control signal

which governed the cutoff frequency of a low pass filter. The low pass filter served to limit the amount of high frequencies in the total input signal transmitted to the output of the Continuous Noise Suppressor. While the device removed continuous noise in varying relationship with the music program, the activity of the control signal was inadequate for total input signals having appreciable continuous noise, in which case the differentiated signal representing noise overwhelmed the signal derived from the band pass filter representing music. In the present invention the control signal is a ratio of the band pass filter and the differentiated signal, resulting in the variations of the control signal even when excessive continuous noise is present. Another advantage of ratioing compared to the prior art is the ability to determine the control signal more quickly and with fewer components. The improved responsiveness of the control signal to the music component of the total signal facilitates the removal of continuous noise without the disturbance of the high frequency music components contained in the total input signal.

The invention has been described in detail with particular emphasis on the preferred embodiment, but it will be understood that variations and modifications within the spirit of the invention may occur to those skilled in the art to which the invention pertains.

What is claimed is:

1. A system for enabling only the transmission of the input signals having the lowest instantaneous noise transient level in the transmitted portion of electrical signals having identical program component of substantially equal signal strength with differing noise transients and transmitted synchronously and simultaneously over separate channels, the existence of such noise transients being reflected by differences between the instantaneous magnitudes of said input signals and an average signal reflecting the average of said input signals, said system comprising:

comparing means connectable to said channels for continuously comparing the total instantaneous signal plus noise magnitude of said input signals to said average signal and actuable in response to the existence of a noise transient in any of said input signals for enabling the transmission of the input signals having lower instantaneous noise transient level with respect to said average signal.

2. The invention according to claim 1 wherein said comparing means comprises:

control means connectable to said channels for generating switching signals indicative of the channels carrying the input signals having lower instantaneous transient noise level with respect to said average signal and

enabling means connected to said switching signals to enable the channels carrying the signals having lower transient noise levels than said average signal to transmit the input signals.

3. The invention according to claim 2 and further including:

low frequency mixing means connectable between said channels for mixing equally into all of said channels all signal components having frequencies below a predetermined frequency level.

4. The invention according to claim 1 and further including means for attenuating the components of said input signals having frequencies below a predetermined low frequency and

wherein said comparing means compares only input signals above said predetermined low frequency.

5. The invention according to claim 3 and further including:

low frequency mixing means preceding said comparing means and connected between said channels;

said comparing means being connected between said channels;

enabling means for enabling at least one of said channels in response to the comparing means, to carry the signals having lower transient noise level than said average signal and to transmit the signals carried thereby;

wherein signal from the low frequency mixer is selected to compensate for the low frequency attenuation and is combined with the signal following the switching means preserving the frequency characteristic of the input signal without noise transients thereby.

6. The invention according to claim 1 and further including:

averaging means connectable to said channels for receiving and combining the respective input signals; and

wherein said comparing means comprises means connectable to said channels and to said averaging means, and actuable for enabling at least one of said channels or said averaging means having lower transient noise level in comparison to said average signal to transmit the signals carried thereby, and when only one of said channels is enabled for disabling the other of said channels from transmitting the signals carried thereby.

7. The invention according to claim 1 and further including:

averaging means connectable to said channels for receiving and combining the respective input signals;

and wherein said comparing means comprises means connectable to said channels and to said averaging means, and actuable for enabling one or both of said channels or said averaging means having higher signal level in comparison to the average signal to transmit the signal carried thereby, and when only one of said channels is enabled for disabling the other of said channels from transmitting the signals carried thereby.

8. The invention according to claim 1 and further including:

averaging means connectable to said channels for receiving the respective input signals and for generating an average signal;

and wherein said comparing means is further connected to said averaging means, said comparing means enabling the channels carrying the signals having lower transient noise level in comparison with the average signal, carrying the signals having the lowest transient noise level to transmit the signals carried thereby.

9. The invention according to claim 1 wherein a pair of said channels each include amplifying means for amplifying the respective input signals of the channels, and wherein said system further includes balance control means for balancing the respective program signal voltages on the pair of channels, said balance control means comprising:

gain adjusting means connected to at least one of said amplifiers to adjust the respective gains of said at least one amplifier in response to the reception of said imbalance signals.

10. The invention according to claim 1 wherein the system includes first and second channels for transmitting said electrical input signals, and said control means comprises:

first rectifying means connectable to said first channel for generating first rectified signals of one polarity corresponding to signals transmitted by said first channel; and

second rectifying means connectable to said second channel for generating second rectified signals having the same polarity as said first rectified signals, and corresponding to signals transmitted by said second channel;

third rectifying means connected to said average signal for generating third rectified signals opposite in polarity to said first and second rectified signals, and corresponding to the combined signals generated by said averaging means;

first polarity determining means for combining said first and third rectified signals and for determining the polarity of the combined first and third rectified signals, and for generating a first switching signal indicative of the one of said first channel and of said average signal having the lowest transient noise level; and

second polarity determining means for combining said second and third rectified signals and for determining the polarity of the combined second and third signals, and for generating a second switching signal indicative of the one of said second channel and of said average signal having the lowest transient noise level.

11. The invention according to claim 10 wherein said first and second polarity determining means each further include threshold means for establishing a threshold value and for preventing the generation of said first or said second switching signals when the absolute magnitude of the differences between either or both of said respective combined rectified signals are less than said threshold value.

12. The invention according to claim 11 wherein the simultaneous generation of first and second switching signals is permitted to occur only if the levels of the signals of the first and second channels are alike within a predetermined ratio.

13. The invention according to claim 1 wherein said comparing means comprises:

first control means connectable to said channels for generating switching signals indicative of signals having the lowest transient noise level, and

first enabling means connected to said first control means, and actuable in response to said switching signals to enable the channel or average of channels carrying the signal having the lowest transient noise level to transmit said enabled signal, and

wherein said system further comprises:

blanking means connectable to said enabled signal for blanking an interval of said enabled signal;

second enabling means electrically connected to said blanking means and actuable for selectively enabling said blanking means to perform the blanking function; and

second control means electrically connected to said second enabling for detecting noise transients in the input signal transmitted by said enabled signal, and for generating actuating signals to actuate said second enabling means in response to the detection of a noise transient.

14. The invention according to claim 1 wherein said comparing means comprises:

first control means connectable to said channels for generating switching signals indicative of the presence of a noise transient having an amplitude above a predetermined value;

first enabling means connected to said first control means, and actuable in response to said switching signal to enable the channel or average of the channels carrying the signal having the lowest transient noise level to transmit said enabled signal; and

wherein said system further comprises:

blanking means connected to said channels for blanking an interval of the enabled signal;

second enabling means electrically connected to said blanking means and actuable for selectivity enabling said blanking means to perform the blanking function;

second control means electrically connectable to said channels for detecting noise transients in said enabled signal and for generating blanking control signals in response to the detection of a noise transient;

third control means electrically connected to said second enabling means and actuable for actuating said second enabling means.

15. A system for enabling the transmission of an input signal having the lowest instantaneous noise transient level in the transmitted portion of electrical signals having identical program component of substantially equal signal strength with differing noise transients and transmitted synchronously and simultaneously over separate channels, the existence of such noise transients being reflected by differences between the instantaneous magnitudes of identical polarity of said input signals, said system comprising:

first and second channels for transmitting said electrical input signals,

first rectifying means connectable to said first channel for generating first rectified signals of one polarity corresponding to signals transmitted by said first channel;

second rectifying means connectable to said second channel for generating second rectified signals opposite in polarity to said first rectified signals, and corresponding to signals transmitted by said second channel;

first polarity determining means connected to said first and second rectifying means, for combining said first and second rectified signals and for determining the polarity of the combined rectified signals, and for generating switching signals according to said polarity;

enabling means for enabling either of said channels in response to said switching signal, to carry only the input signal having the lowest magnitude and to transmit only the signals carried thereby;

second polarity determining means connected to said first and second channels for determining if the input signals are of the opposite polarity, to disable the switching signals there upon.

16. A system for reducing the noise transients in an input signal transmitted over a channel, said system comprising:

first and second filter means connected to said channel for transmitting different bands of frequencies therethrough;

first and second blanking means connected to said channel for respectively blanking first and second bands of frequencies in the input signal transmitted by said channel;

first and second enabling means electrically connected respectively to said first and second blanking means and actuatable for selectivity enabling said first and second blanking means to perform the blanking functions; and

first and second control means electrically connectable to said filters for detecting noise transients in the input signal transmitted by said channel and for generating blanking control signals in response to the detection of a noise transient.

17. The invention according to claim 16 wherein the blanking levels of said first and second blanking means are in predetermined relationship with said levels in first and second bands of frequencies during a predetermined time interval prior to blankings.

18. The invention according to claim 16 wherein:

said first and second filter means transmit relatively lower and higher bands of frequencies, respectively;

said first and second blanking means are connected to said first and second filter means, respectively, for blanking the lower frequency and higher frequency bands in independent time portions of the input signal transmitted by said signal;

and further comprising:

disabling means electrically connected to and preventing operation of said first enabling means when said second enabling means has not been enabled.

19. The invention according to claim 18 wherein said second enabling means provides a predetermined time interval during which said first blanking means can be enabled by said first enabling means.

20. The invention according to claim 16 wherein said second control means comprises:

low pass filter means for transmitting said input signal exclusive of the high frequency transient noise components of said input;

peak voltage generating means electrically connected to low pass filter means for transmitting a first signal reflective of the instantaneous voltage from the low pass filter;

comparing means electrically connected to said first signal and to the input of the second control means constituting a second signal; for generating a noise indicator signal when the first signal exceeds in amplitude the second signal;

gain adjustable means for adjusting the gain of the peak voltage means with respect to the input of said second control means by a predetermined amount; and

means for connecting said second control means to said second enabling means, for actuating said second enabling means to produce said second blanking signal.

21. The invention as in Claim 20 where the input of second control means is connected to the output of the second filter.

22. The invention according to claim 20 wherein said gain adjustable means further includes a predetermined combinable dc bias voltage such that the gain adjustable signal is at least as great as that of the dc bias voltage.

23. The invention according to claim 20 wherein said low pass filter means further comprises:

disabling means for preventing the transmission of signal therethrough; and
means for connecting said disabling means to said first enabling means, the
actuation of said first enabling means furthermore actuating said disabling means.

24. The invention according to claim 23 wherein said disabling means is actuated for a predetermined time interval initiated by a triggering signal from the first enabling means.

25. The invention according to claims 23 ~~and 24~~ wherein said peak voltage generation means further includes signal retention means such that the voltage stored thereby is not significantly attenuated during the time interval that said disabling means is enabled.

26. A system for suppressing noise in an input signal, comprising:

first means for producing a first signal proportional to the peak amplitude of the
rate of change with respect to time of the input signal;

second means for producing a second signal proportional to the instantaneous
amplitude of the input signal;

selection means for selecting an operating frequency band for use with the second means, the second means producing the second signal proportional to the instantaneous amplitude of the portion of the input signal falling within the selected frequency band;

control and ratio means for dividing the first or second signals by the other to obtain an indication of the noise in the input signal relative to the amplitude and frequency characteristics of the input signal and for generating a control signal according to said indication; and

filtering means having a cut-off frequency selected in response to said control signal, said filtering means filtering from the input signal components of the input signal according to the selected cut-off frequency to suppress noise in the input signal.

27. The system according to claim 26, wherein the first means comprises differentiating means shunted by capacitive and resistive means for producing a signal proportional to the peak amplitude of the time rate of change of the input signal.

28. The system according to claim 26, wherein the selection means for selecting an operating frequency band comprises a band pass filter.

29. The system according to claim 26 and further including means establishing a predetermined time delay interval, and means for making said control signal unresponsive to noise transients occurring in said channel having durations less than said interval.

30. The system according to claim 29 wherein the duration of the time delay interval is at least 1 millisecond.

31. The system according to claim 26 and further including means for combining predetermined dc voltage with said control signal such that the control signal attains a voltage magnitude at least that of the dc voltage.

32. The system according to claim 26 and further including metering means electrically connected to said control signal, said control signal also connected to said filtering means for suppressing noise from said input signal, wherein said metering means is responsive to said cut-off frequency.

33. The system according to claim 26, wherein said filtering means comprises at least one cascaded single pole filter.

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I hereby claim the benefit under Title 35, United States Code §120 of any United States application(s), or extension of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

| | | | | | | | |
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| Inventor's Signature | Thomas N. Packard | | | | Date | March 30, 1999 | |

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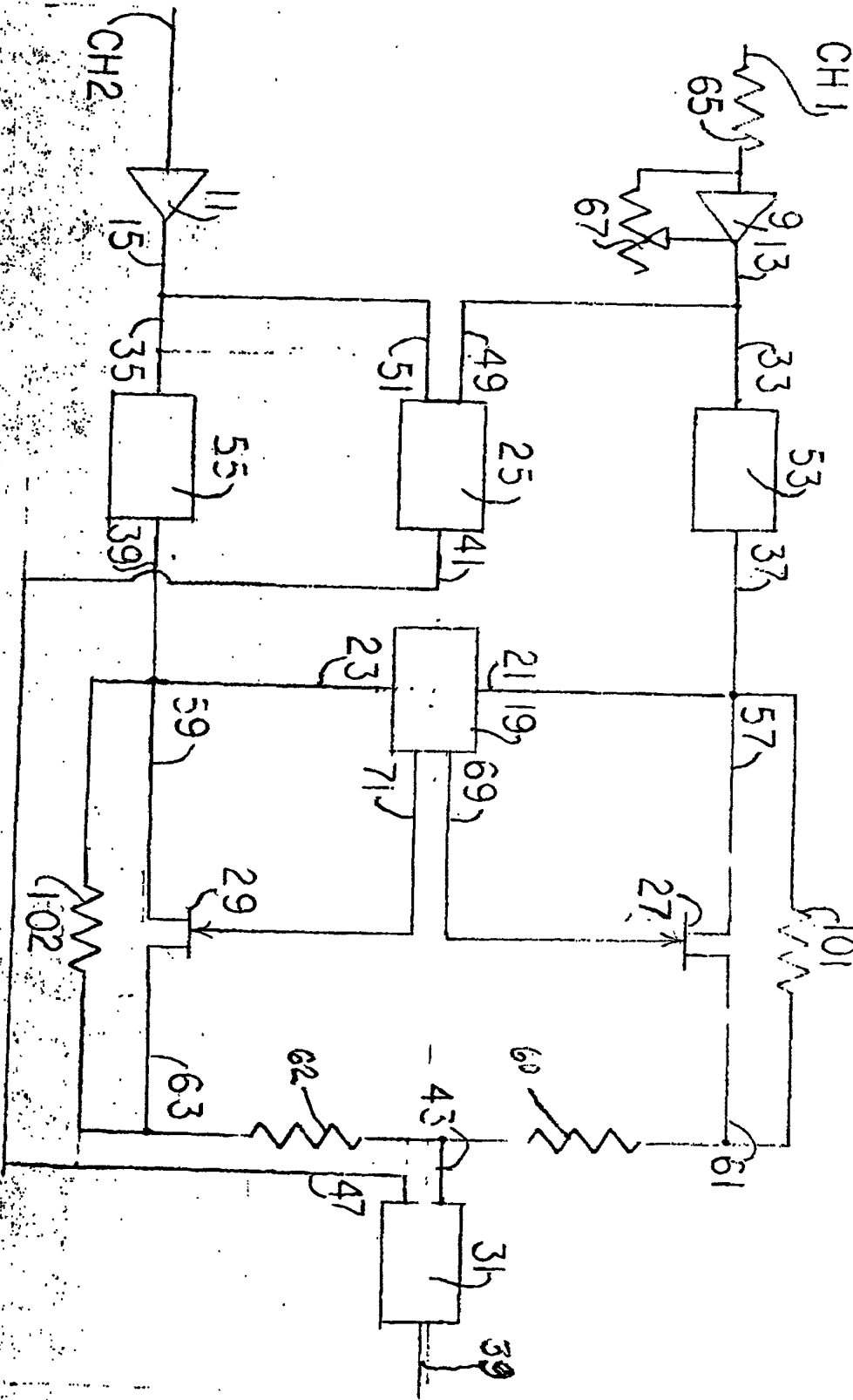
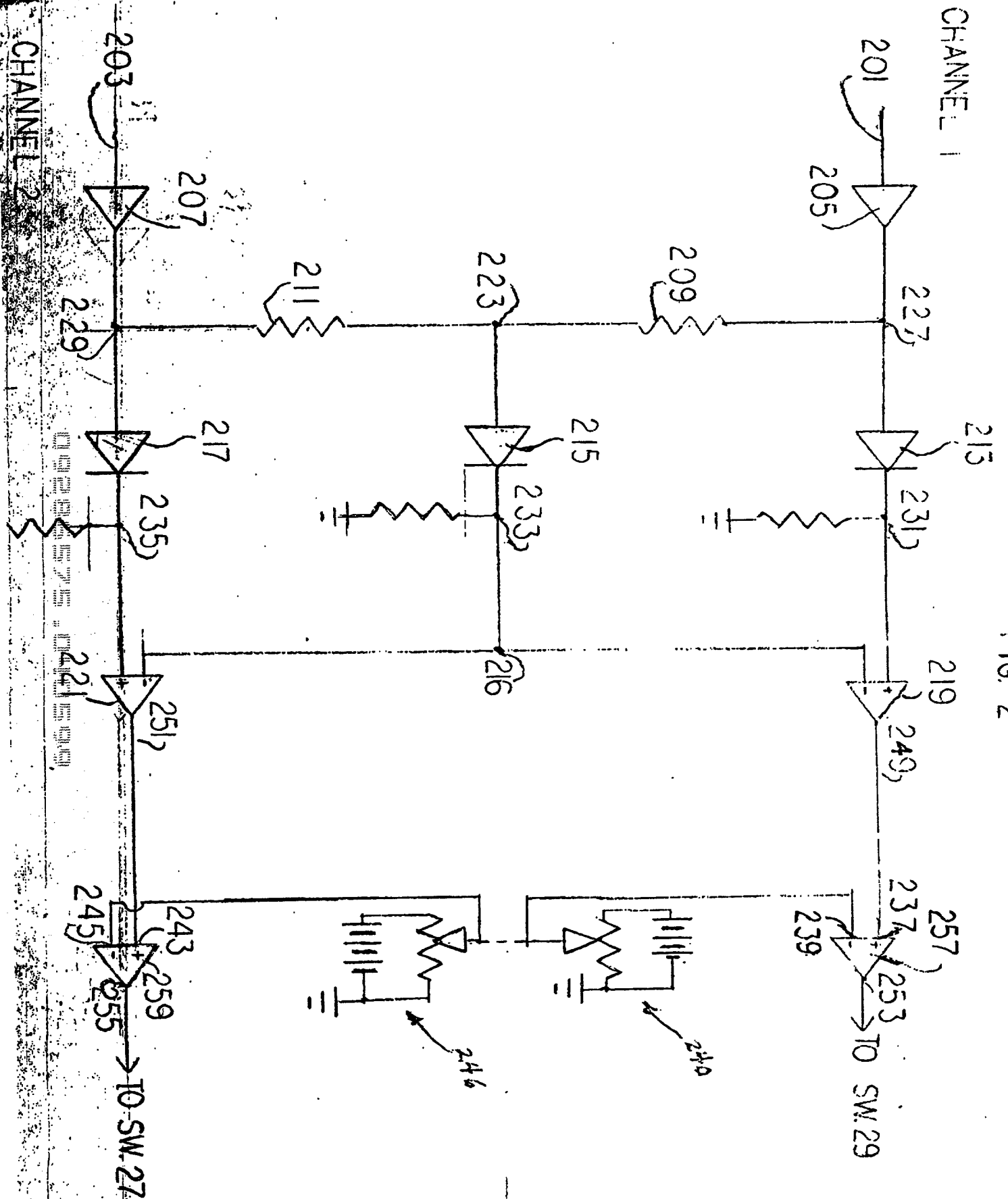


FIG. 1

FIG. 2



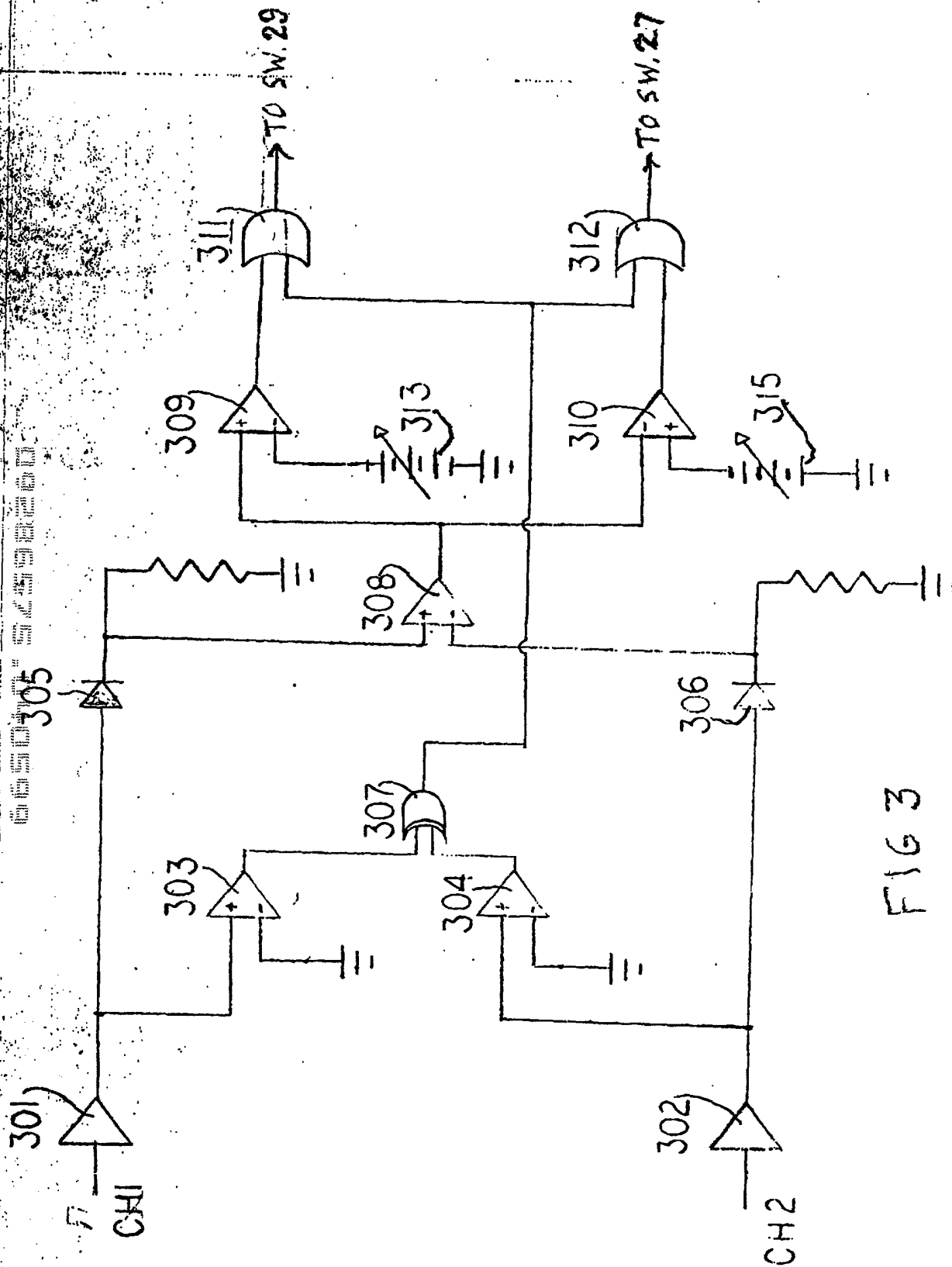


FIG 3

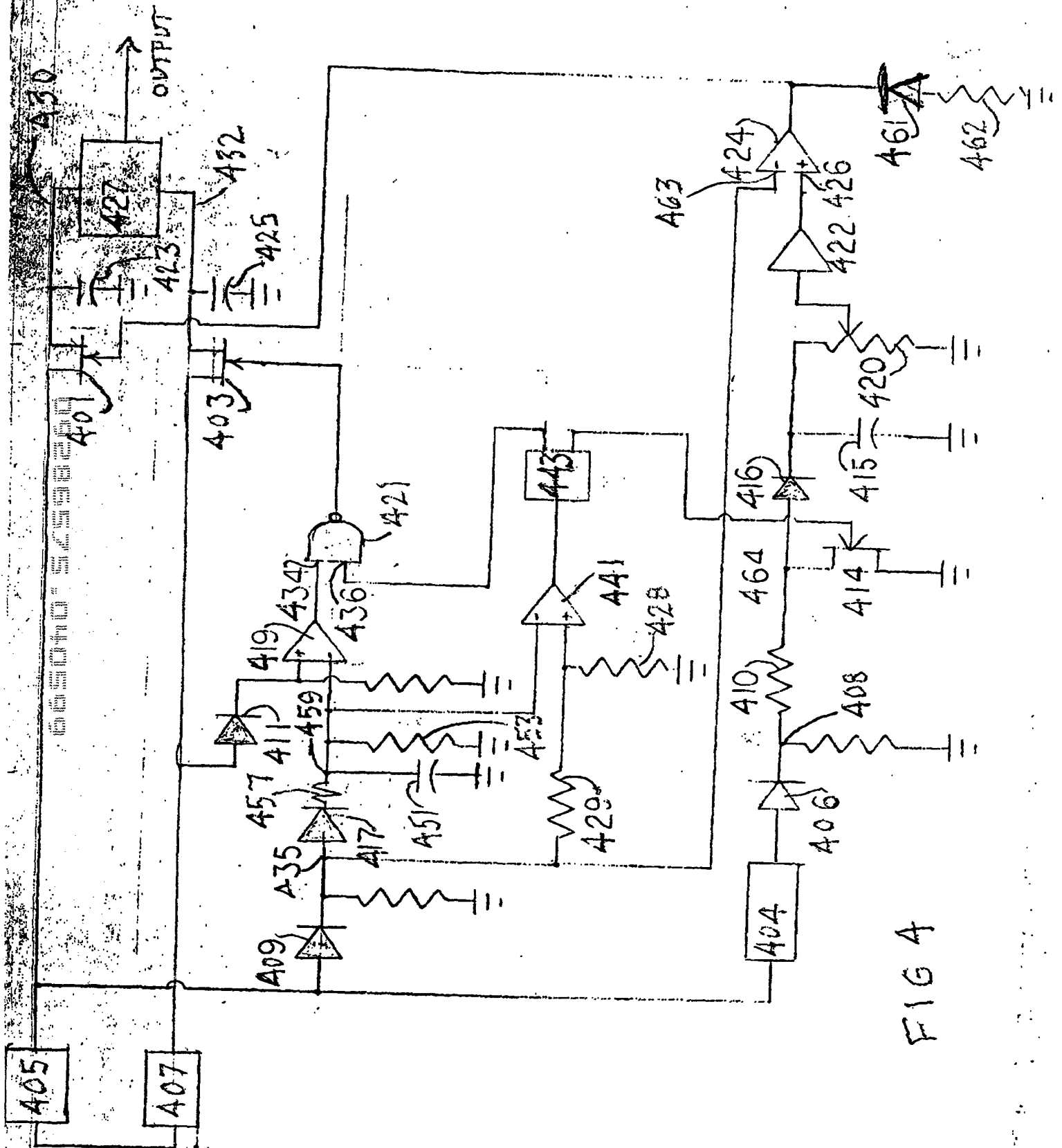
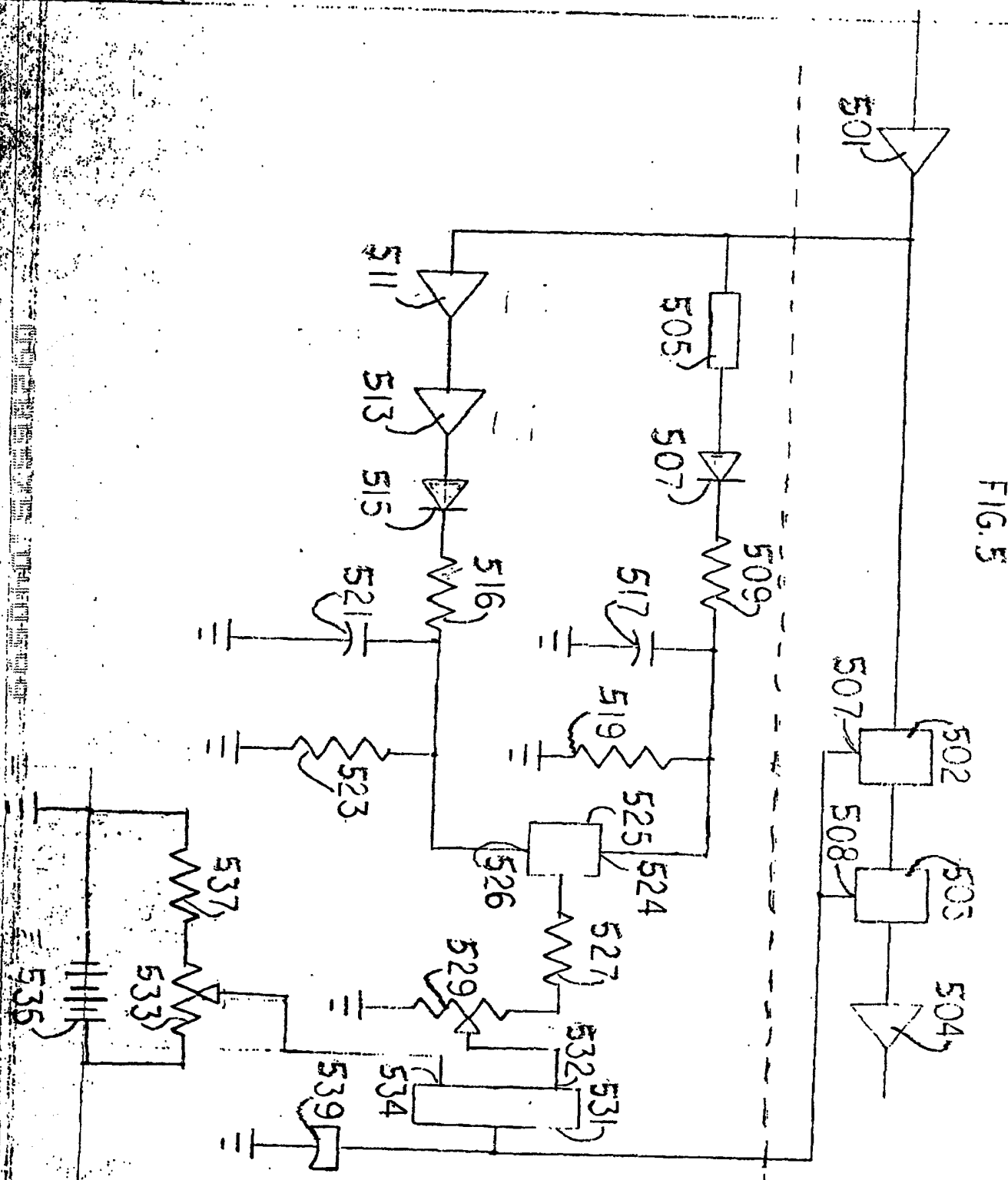
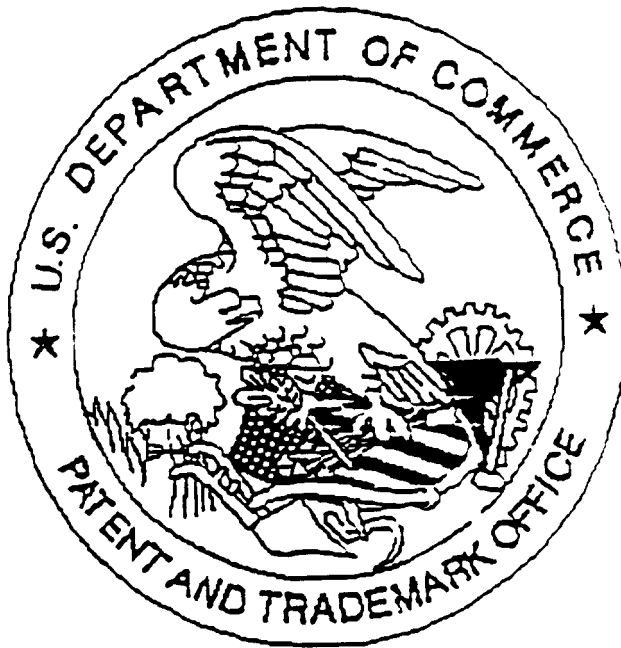


FIG 4

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